Commercial Ice Navigation
A Paradigm Shift

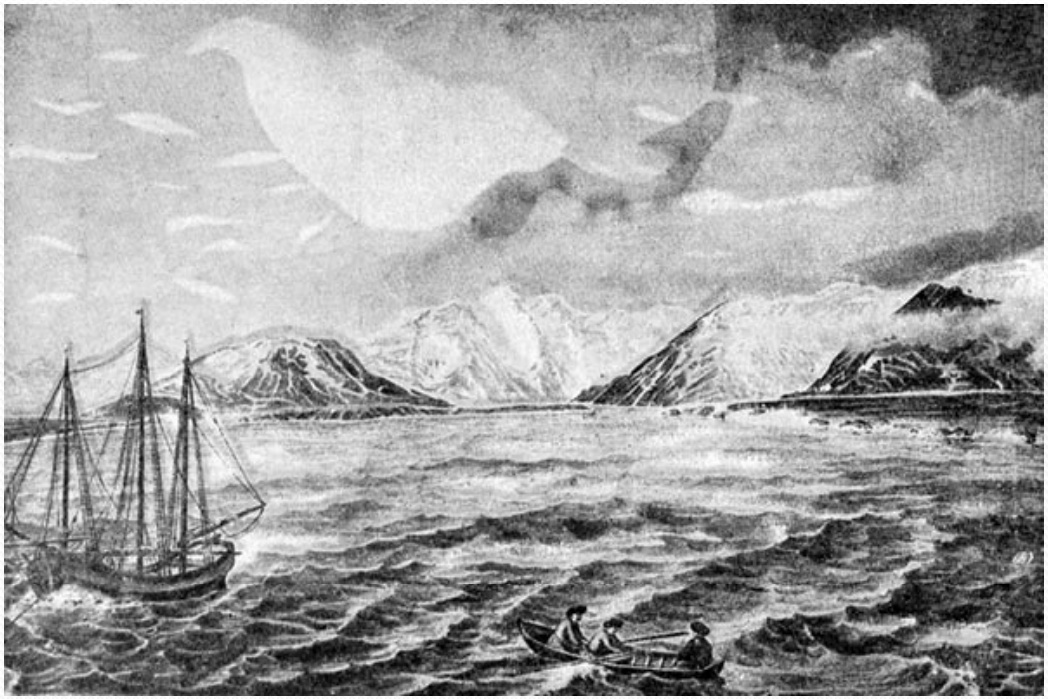
April, 2006

Early Arctic Exploration

- Russia Leads the Way
  - ✓ Pomors from the town of Novgorod launch whaling and sealing expeditions into the White Sea and along the Murmansk coast as early as the 12th century
  - ✓ In the 16th and 17th centuries, European Monarchs desired to find an alternate trading route to China via the NSR and NW Passage

Early Arctic Exploration

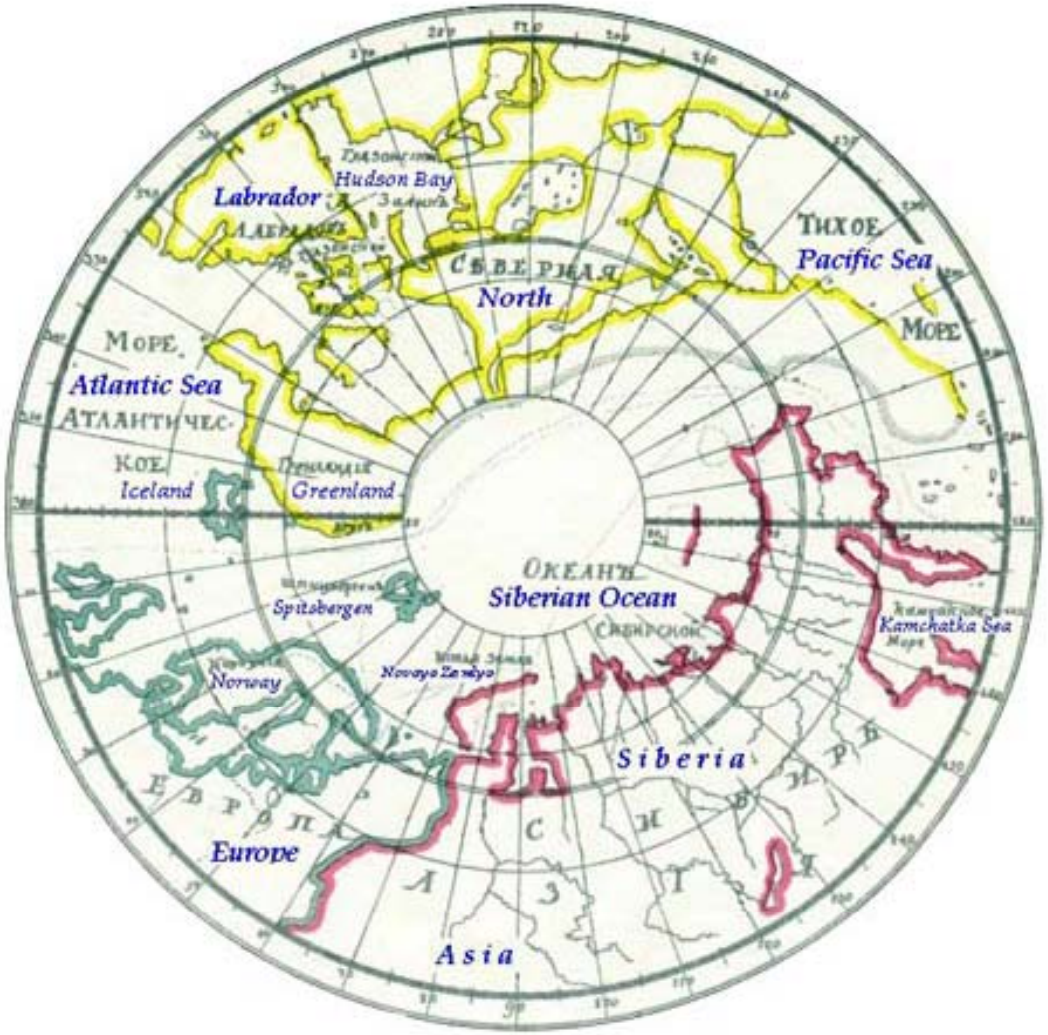
- Russia Leads the Way
  - ✓ In the 18th and 19th centuries Peter the Great sent Vitas Bering to search for a route to America and Japan
  - ✓ These "Great Northern Expeditions," mapping the coast of Siberia continued for 20 years.



Matochkin Shar Strait, Novaya Zemlya.

Early Arctic Exploration

- Supported with scientific instruments, charts, and other technologies Russian physicist and philosopher, Mikhail Lomonosov examined the gathered data and determined that the ocean encompassed the North Pole
- He defined the currents in the Arctic Ocean, described ice drift mechanics, and classified sea ice types
- His Arctic map published in 1763 was revolutionary for its time
- Lomonosov's findings supported future Russian excursions such that the coast of Alaska was populated with several Russian settlements before the end of the 18th century



Ice Breaking History

- USCG Bear purchased for the Greely rescue mission 1884
  - ✓ Converted whaler with reinforced hull
  - ✓ Light ice capability
  - ✓ Served in Alaskan waters for over 40 years
  - ✓ But wooden hulls could not withstand crushing ice loads

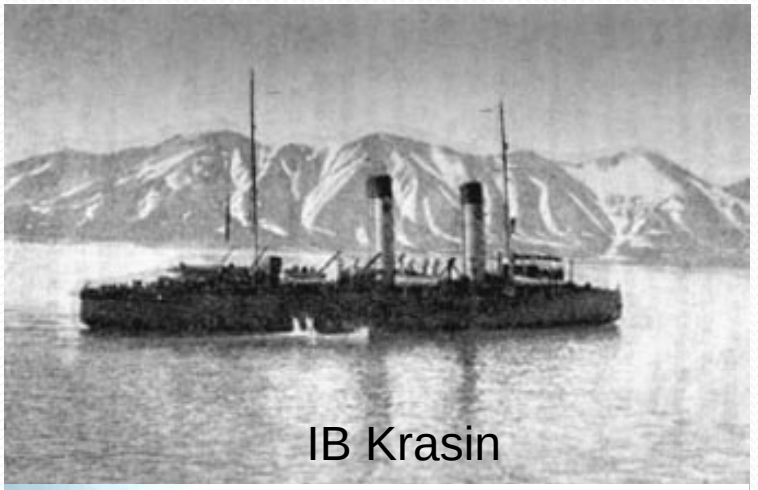
Early Icebreakers

- Advances in shipbuilding technology resulted in the icebreaker, a vessel able to both withstand the crushing power of the ice and break through it.
- In Russia, Britnev circa 1864 proposed the characteristic bow shape that is now used by all icebreakers.
- The first notable icebreaker was the steam and sail powered *Pilot* (1870), used to maintain communication between Kronstadt and St. Petersburg.
- Naval Commander Makarov is credited with the construction of the *Yermak*, the first true icebreaker, which reached 81°21'N north of Spitsbergen on her maiden voyage in 1899, and 83°06'N nearly 40 years later.

IB Yermak

Russian Icebreakers

- In 1916, the first linear icebreaker supporting regular navigation along the northern coast of Russia was built in Newcastle, England to Russian Maritime Ministry specs, and named the *Krasin*. This icebreaker was a crucial component in the development of the Northern Sea Route until the late 1930s
- Soviet IB Arctika, was the first surface ship to reach the north pole in 1977
- Launched in 1992, the Yamal is a modern nuclear IB of 75,000 HP displacing 23,000 tons. One of five sisters it can break ridges of 9 meters and sail thru 2.3 meter ice at 3 knots.
- With a beam of 28 meters, these ships are designed to keep shipping lanes open, but also offer passenger cruises to the North Pole

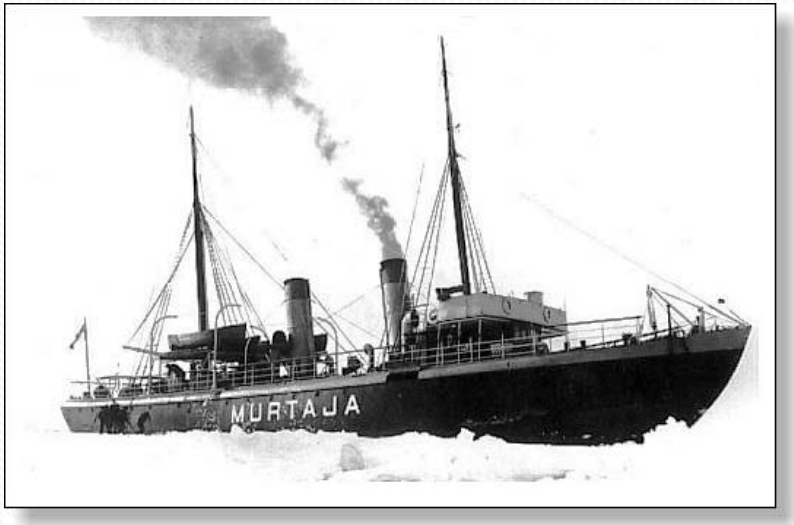


IB Krasin

IB Yamal

Finnish Icebreakers

- More than 80 per cent of Finland's foreign trade involves seaborne transport. In winter, cargo vessels rely heavily on the assistance of icebreakers to lead them safely to port. Finland has roughly 1,500 kilometres of coastline on the Baltic Sea and about 60 ports. For over 100 years Finland has relied on IB technology to maintain trade.
- Finland´s first icebreaker Murtaja, built in 1890, was described as the "newest, biggest and strongest icebreaker in Europe". It opened the frozen winter sea to commercial shipping
- In 1926 the Jaakarhu was the first IB to use oil as fuel which increased range



Finland - Worlds Leader in IB Design and Construction

Aker takes the technology lead:

- ✓ forerunner in diesel-electric icebreakers (1939)
- ✓ first four-screw icebreakers
- ✓ first polar icebreakers
- ✓ first shallow-draught river icebreakers
- ✓ first AC-AC drives in icebreaker application
- ✓ first air bubbling systems
- ✓ first stainless steel icebelts installed
- ✓ first Azipod developed
- ✓ first double-acting ship developed
- ✓ first oblique vessel developed

Aker Arctic Research Center & Aker Yards

Building Ice Breakers for Many Countries

- ✓50 years of icebreaker design and construction
- ✓ 60 per cent of all icebreakers built, continuous
- ✓ professional skill learning, cumulative know-how
- ✓ 300 model tests, every constructed vessel also full-scale tested in real conditions, world´s best correlation database
- ✓ Arctic Technology Center AARC continuosly work for all oil majors (Exxon, Shell, ConocoPhillips, ChevronTexaco, BP, Norsk Hydro, Statoil, Agip, Fortum, LUKoil, Gazprom) and leading shipping companies as well as shipyards
- ✓ New innovations and technical solutions created and accepted by the industry

Typical IB Passage

- IB operation is simple and until recently hasn't changed for 100 years.
- The icebreaker leads the way, its armor plated bow section rising slightly above the sea ice and cracking it like the action of a hammer. A channel of open water begins to advance into the ice field.
- The merchant vessels follow in the wake of the leading IB.

Typical IB Passage

- In extreme conditions the icebreakers go one step further, taking merchant ships in tow and delivering them to harbor safe and sound.

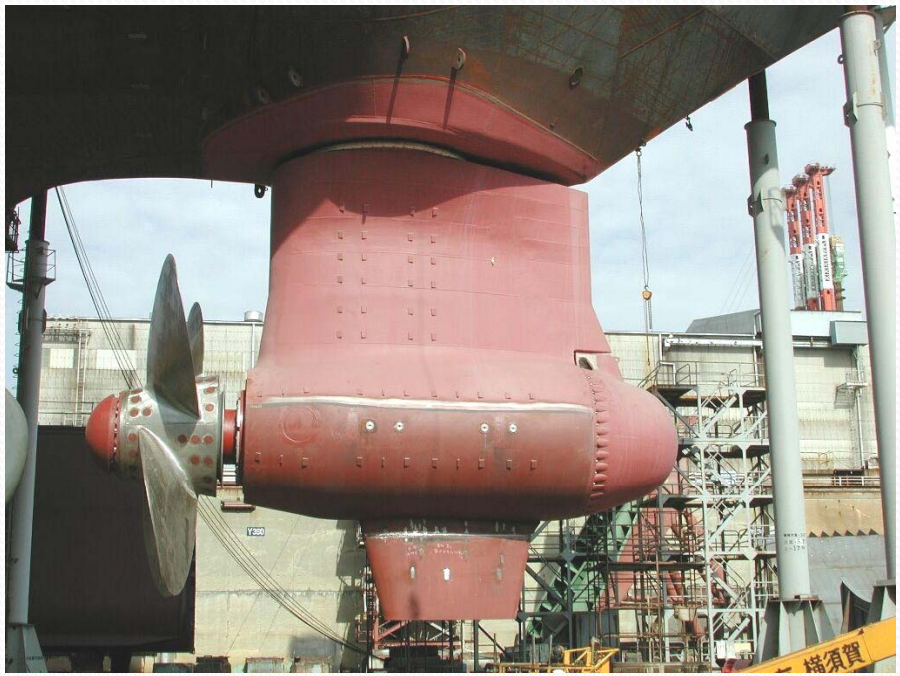
Traditional Escorted Transits are Expensive

Over 140+ years of Ice Breaking Transits

Its Time to Change the Game

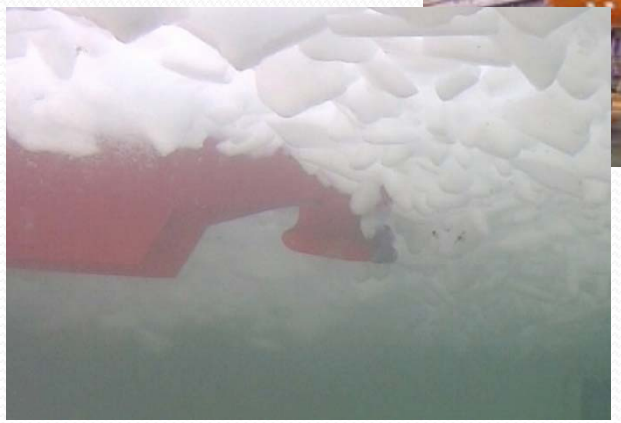
Game Changing Azipod Propulsion

- ✓ The Azipod® is a podded propulsion system, azimuthing through 360°C, in power ranging from 5MW to 30MW.
- ✓ It incorporates an electric motor mounted directly on an extremely short propeller shaft. The motor drives a fixed-pitch propeller. The motor is controlled by a frequency converter which produces full nominal torque, smooth and stepless, in either direction over the entire speed range, including standstill.



Double Acting Vessels – Set, Match

- ✓ IB Captains long ago noted that their vessels could break ice running astern almost as well as running ahead.
- ✓ If Azipod propulsion was employed, Aker determined that reinforced ice breaking sterns could be designed to efficiently break ice
- ✓ Ice basin model test confirmed that running astern using Azipod propulsion was actually more efficient



Double Acting Vessels – Set, Match

Ahead if by Sea

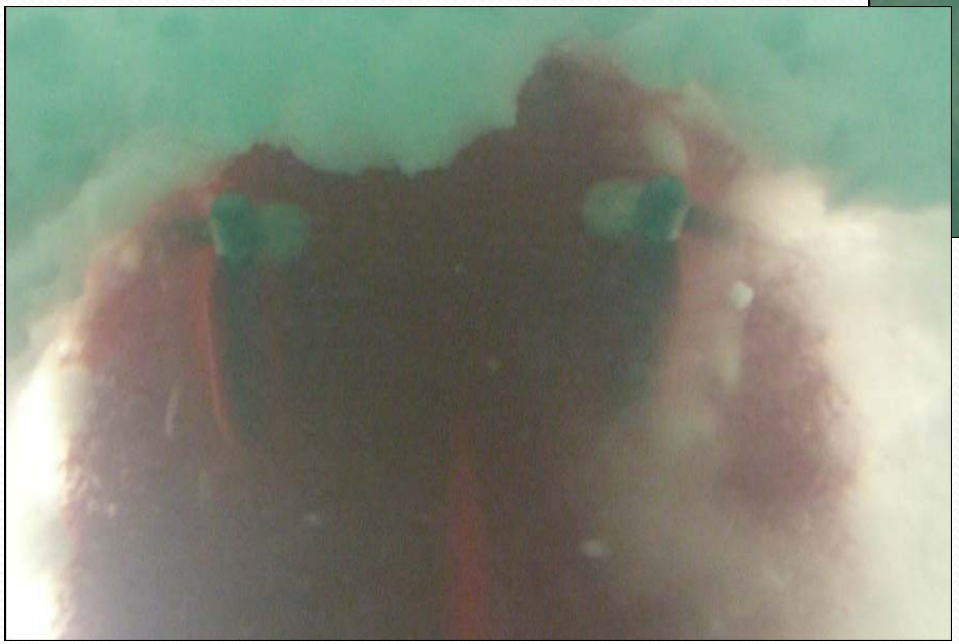
Astern if by Ice

DATs - A Practical Success

- ✓ The first double-acting cargo ship (DAS) were introduced in 2002
- ✓ The 106 000 tdw M/T ”Tempera” and ”Mastera” have verified their superior ice performance in the difficult ice conditions in shuttle service to Primorsk
- ✓ With the 16 MW pod drive they were able to achieve a speed of 6 knots in 70 cm thick ice and break independently through 13 meter deep ridges
- ✓ The vessel did not require any icebreaker assistance during the whole winter and in fact acted as icebreakers themselves to other merchant ships

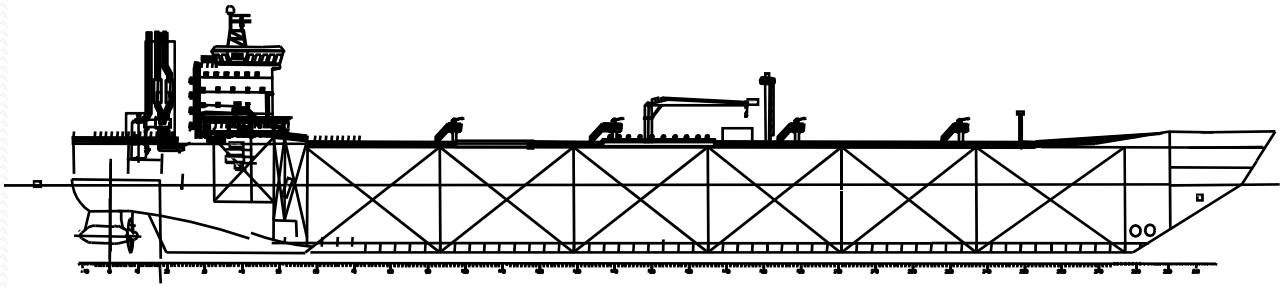
Ice Basin Tests

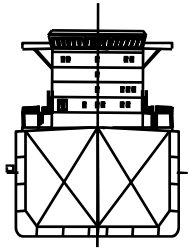
Fast Ice meets a modeled ice ridge equivalent to 12 meters deep, 300 meters wide



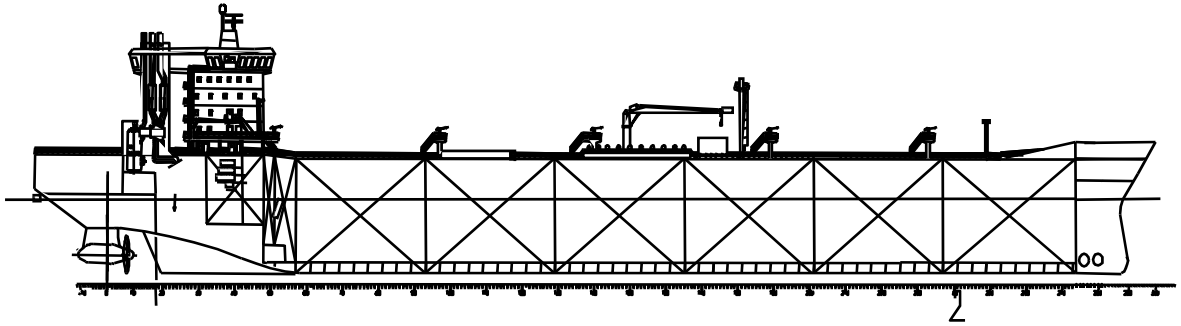
Azipods chew through ice ridge. Vessel continuously moving forward. No ramming required

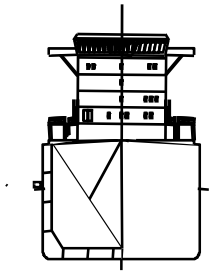
Ice ClassTanker LU7 Comparison (75,000 dwt)





Conv.
25 MW

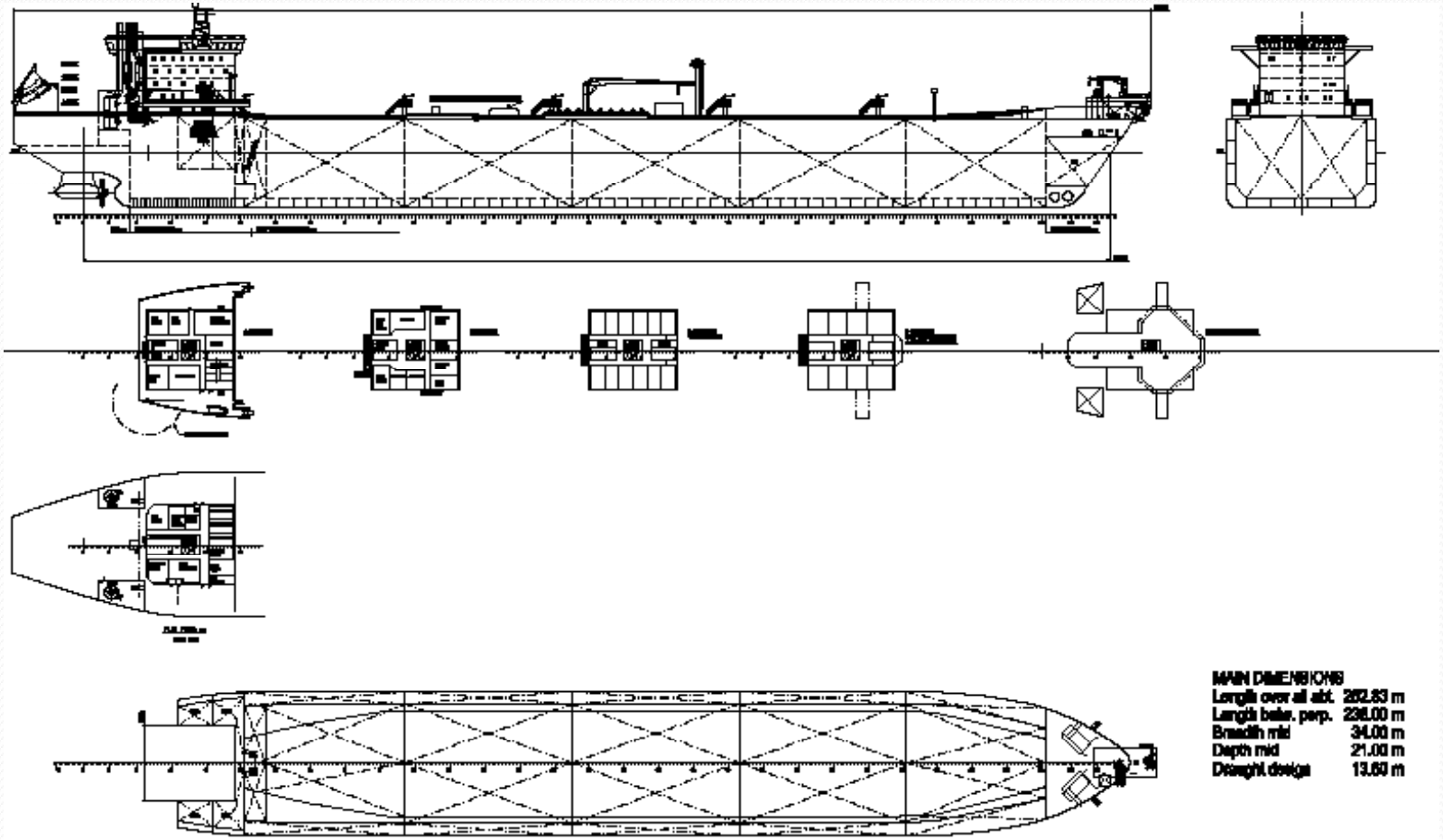




DAT
17 MW

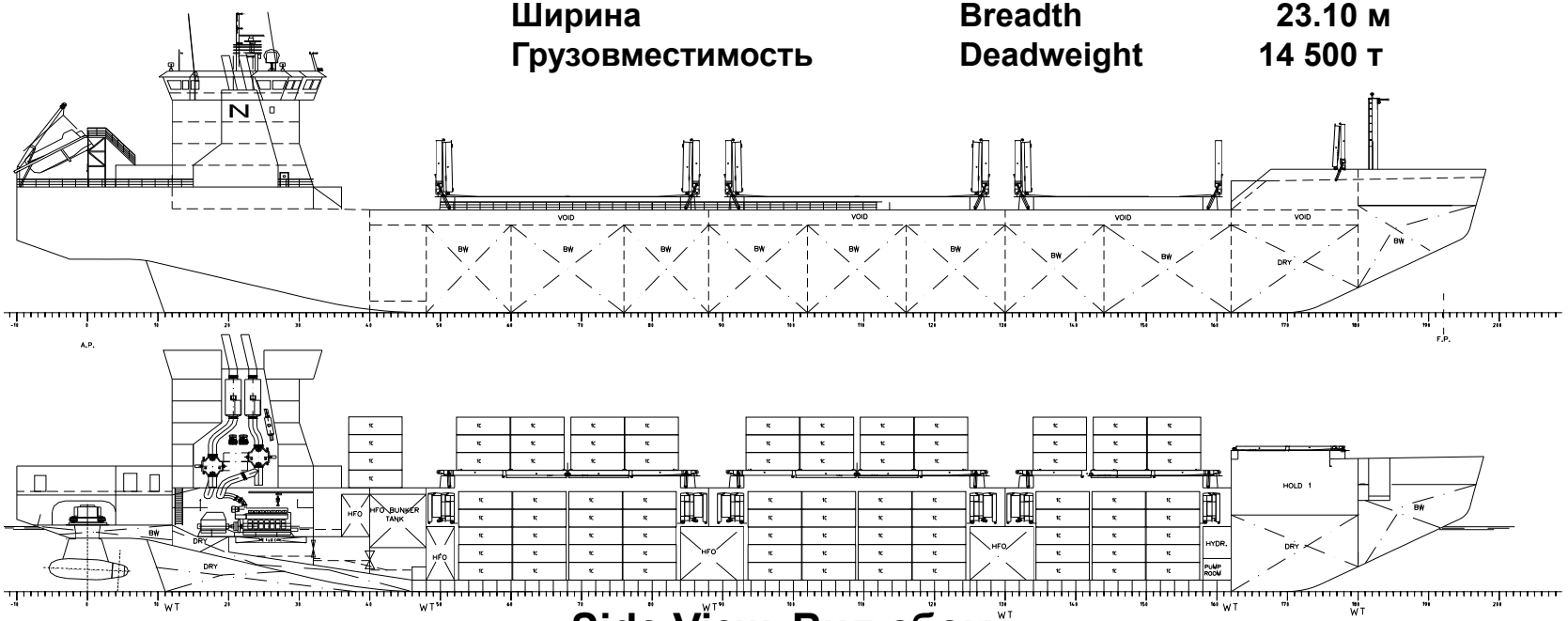
Same cargo capacity in smaller hull, and modified bow provides more speed in open water

Two 70,000 dwt DATs for the Pechora



13 MW Azipod DAS solution for Kara Sea and Yenisei

Длина	**Length**	**164.90 м**
Ширина	**Breadth**	**23.10 м**
Грузовместимость	**Deadweight**	**14 500 т**



Side View, Вид сбоку

Ice Class LU 7

Design for an Arctic container vessel, shuttle service Dudinka-Dikson-Murmansk/Archangelsk

From Design to Reality

Giving the Ship a Rest !

North of Novaya Zemlaya

1.5 m first year ice

Avg speed – 5 knots

10 m ridge

Avg spd ahead – 1.5 kts

Avg spd astern – 2.0 kts

Actual voyage pictures March 2006

Arctic LNG Project Design Basis

- ✓ LNG, LPG, and condensate production transported from Russian Arctic to Rotterdam
- ✓ Unlimited, year round operation in the Kara Sea between Ob Bay and the ice edge west of Novaya Zemlaya, to LNG receiving terminal
- ✓ Operating condition: Severe winter operation with no ice breaker assistance

Project Description

- ✓ Storage and Loading Terminal West Coast Yamal
- ✓ Concrete Gravity Based Structure
- ✓ Storage Volumes
  - ✓ 300,000 m3 LNG
  - ✓ 80,000m3 C3, 40,000 m3 C4
  - ✓ 160,000 bbl Condensate
- ✓ 20 meter water depth

Terminal Layout

- ✓ Located in one year fast ice
- ✓ Orientation to facilitate ice removal and ice management
- ✓ Open harbor maintained with multipurpose ice utility boat

Total Solution - Proven DAT Design

- ✓ Diesel Electric Propulsion: Dual fueled Wartsila DF50 engine
- ✓ Dual Azipod drives
- ✓ Ice breaking stern
- ✓ Modified ice bow for thin ice and open water
- ✓ Bow thruster

DF 50 Reliability and Redundancy

The Wärtsilä 50DF has inherited reliability from the Wärtsilä Vasa 32 and Wärtsilä 46 diesel engines, respectively.

In addition, the Wärtsilä 50DF carries a lower mechanical load.

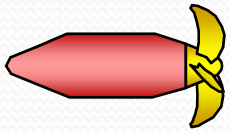
Furthermore, they are running on cleaner fuel than the conventional diesel engines.

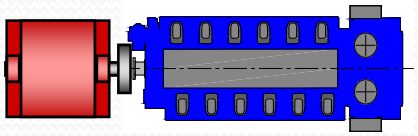
High availability can be guaranteed.

Electric propulsion systems have basically been invented to provide maximum redundancy.

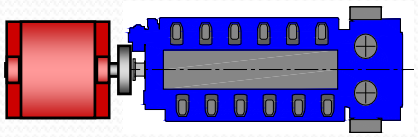
On LNG carriers, a reasonable amount of redundancy will be sufficient.

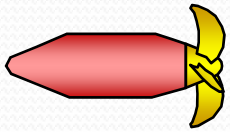
Propulsion Configuration

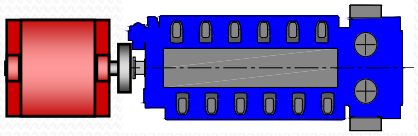




Podded propellers







Ice Management

Multi purpose double acting utility vessel

- ✓ Capable of clearing ice from harbor
- ✓ Capable of safely berthing LNGC
- ✓ Note: Because DAT LNGCs are highly maneuverable, number of utility vessels to be defined

Cost Indications

- ✓ LNGCs about 1.4 x cost of standard carrier for equivalent size
- ✓ Utility vessels 1.5 x cost of standard harbor tug
- ✓ Ice breaker escort costs – no costs at this time
- ✓ NSR Tariff reduction expected or eliminated
- ✓ Use MSC IB escorts in difficult ice conditions or breakdown situations
- ✓ Fuel cost – Economic, dual fueled diesel
  - ✓ MDO
  - ✓ HFO
  - ✓ BOG

The Future is Astern of Us